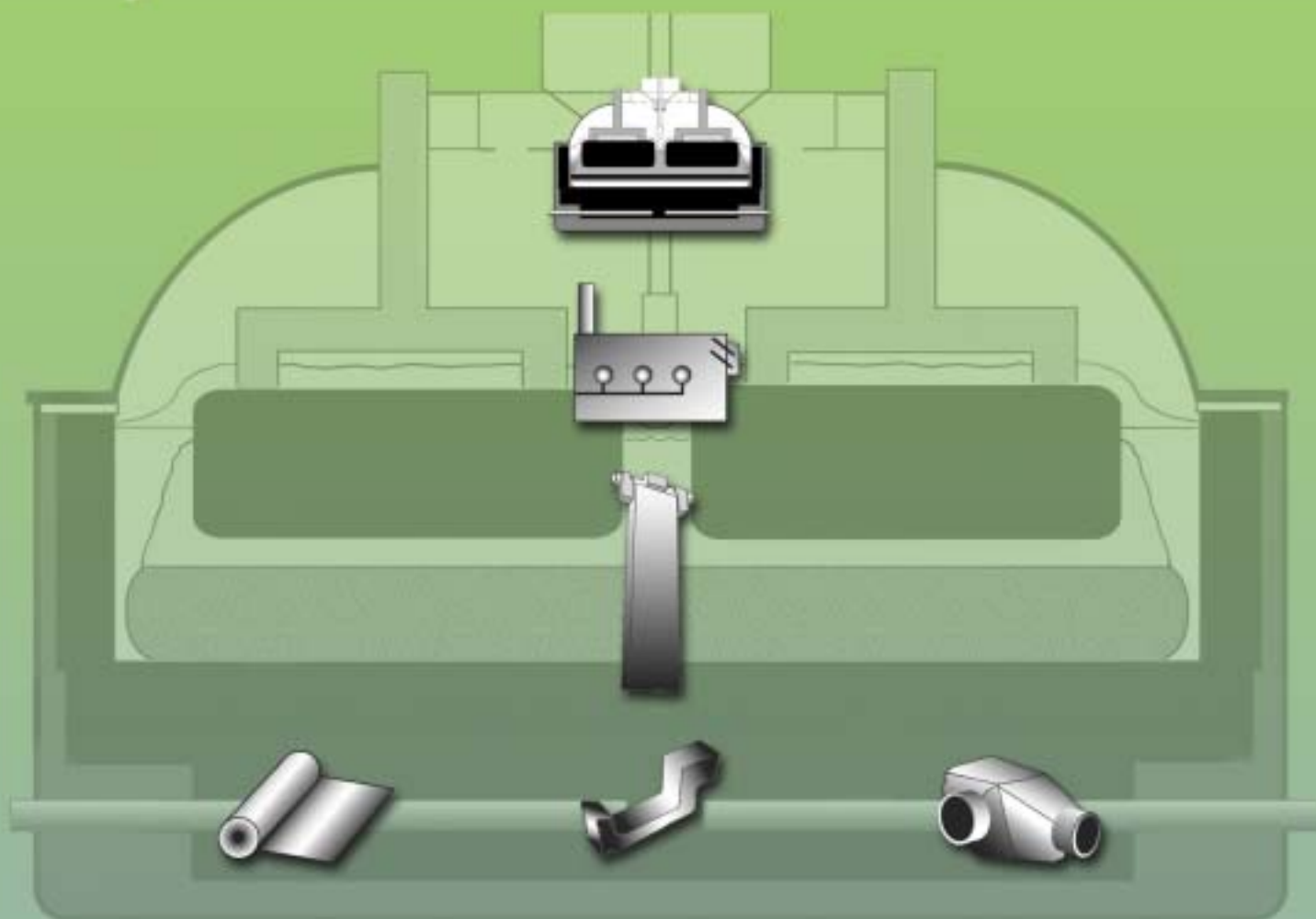


Aluminum



Aluminum Annual Report Fiscal Year 2003

Industrial Technologies Program

Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy’s (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. Through an innovative strategy known as Industries of the Future (IOF), EERE’s Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private-sector investment.

The IOF strategy maximizes the energy and environmental benefits of ITP’s process-specific technology investments by forming collaborative partnerships with energy-intensive industries. These collaborations aim to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The IOF public-private partnerships also facilitate voluntary efforts, such as the President’s Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions. ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 75 percent of industrial energy consumption:

- | | | |
|-------------------|-----------------|----------------------|
| • Aluminum | • Glass | • Petroleum Refining |
| • Chemicals | • Metal Casting | • Steel |
| • Forest Products | • Mining | |

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the IOF partnerships have generated significant energy and environmental improvements that benefit the nation and America’s businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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EXECUTIVE SUMMARY

Aluminum is an indispensable metal to modern manufacturing. Its low density and corrosion resistance make it the metal of choice for many manufactured products ranging from spacecraft components to beverage cans. The aluminum industry consumed nearly 800 trillion Btu in 2000 and produced over \$39 billion in products that are vital to U.S. manufacturing. The industry is responsible for approximately 1.8 percent of the total manufacturing energy consumed in the United States and 1.6 percent of all U.S. electricity consumption. Energy-intensive operations consist of the primary production from ore, secondary production from scrap, shape casting, rolling, and extrusion. ITP's Aluminum Industry of the Future (IOF) cost-shares pre-competitive research and development (R&D) to improve the energy efficiency of these operations. It fosters research partnerships and has been credited as the driving force behind many significant technical advances that will lower energy consumption by an estimated 59 trillion Btu in 2010.

The Aluminum IOF R&D activities utilize industry, academia, and national laboratory resources. Partnerships established around cost-shared projects ensure that the R&D activities undertaken are of useful and commercial value to the industry. This approach accelerates the rate of new product diffusion and garners energy efficiency benefits earlier than the traditional R&D-to-market product life cycle. These multi-team partnerships also introduce hundreds of university and graduate students to the aluminum industry. This ensures a well-educated and well-trained workforce, which is imperative for the aluminum industry to remain innovative and competitive in the global economy. To guide research, aluminum industry stakeholders developed a vision (updated in 2001) that establishes goals and technology roadmaps that chart the R&D pathways to achieve these goals. These documents form the basis for open and competitive R&D solicitations that address the energy efficiency goals outlined in the *National Energy Policy*, as well as the aluminum industry's research priorities.

This successful government-industry partnership continues to focus on developing high-impact research projects to make revolutionary improvements in energy efficiency in the aluminum industry. The following summarizes major highlights and accomplishments of the Aluminum IOF during FY 2003 and provides a snapshot of the Aluminum IOF research portfolio.

Research Portfolio

- The 31 projects in the FY 2003 Aluminum IOF research portfolio involve 69 partners from industry, suppliers, academia, and national laboratories working in 23 states to improve the energy efficiency of the industry. These projects range from one to three years in duration and will expend over \$62 million Federal and industry cost-share to address the research needs identified by the industry in their vision and roadmap documents. The involvement of industry at the inception of the development accelerates technology transfer and dissemination of research results.
- The Aluminum IOF funds a focused portfolio of research on primary, melting/thermal, and forming operations. Fifty percent of Aluminum IOF funding is directed toward lowering primary metal energy consumption. This is the area with the largest opportunities for improving energy efficiency. In addition to the Aluminum IOF research funding, other IOF and EERE programs have leveraged more than \$25 million on research and technical assistance that directly impacts the aluminum industry.

Current R&D and Project Successes

- Researchers are demonstrating the technical, economic, and environmental viability of carbothermic reduction for primary aluminum production. These researchers have addressed substantial engineering hurdles related to the materials-of-construction for high-temperature reactors, recovery of aluminum vapor, and process controls for the complex multi-stage chemical reactions. ITP estimates that this new technology will save 19.2 trillion Btu and \$108.3 million in operating costs per year in 2020.
- Research has led to the development of an innovative vertical flotation melter that uses the thermal energy in exiting flue gases to preheat scrap aluminum for secondary metal production. Emissions of

NO_x, SO₂, CO, and VOCs from this process have been measured well below traditional scrap melting furnaces. ITP estimates that this technology will save 9.9 trillion Btu with a \$34.8 million in energy cost savings per year in 2020.

- Researchers have developed a new probe and filter technology for detecting and removing salts and particulates from molten aluminum. This new technology increases casting yields by lowering the defect rate. It is estimated that this scrap-reducing technology will save 40 billion Btu annually.
- Researchers have developed and demonstrated a high-efficiency, high-capacity, low-NO_x combustion system integrated with an innovative low-cost, vacuum-swing adsorption oxygen system. This technology provides a 30 percent improvement in furnace productivity and a 40 percent reduction in fuel consumption relative to air-fuel furnaces used for aluminum melting. ITP estimates that this technology will save 1.5 trillion Btu with a \$5.2 million in energy cost savings per year in 2020.

IOF Accomplishments

- The Aluminum IOF performs outreach activities to disseminate R&D results and accelerate adoption of developed technologies. The Aluminum IOF and 14 of its partners presented papers related to the Aluminum IOF portfolio at the 2003 Minerals, Metals, and Materials Society's (TMS) 132nd annual meeting. The Aluminum IOF also presented at the American Council for Energy Efficient Economy (ACEEE) Industrial Summer Study.
- The North American aluminum industry updated, in 2002, the 1997 *Aluminum Industry Technology Roadmap* with a new document that defines specific R&D priorities, performance targets, and milestones required to achieve the goals set out in the 2001 *Aluminum Industry Vision: Sustainable Solutions for a Dynamic World*.
- The Aluminum IOF performed an in-depth analysis of energy use in the aluminum industry to benchmark energy-intensive processes/technologies and to identify where major energy savings can be achieved. The *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities* report provides energy-performance benchmarks for evaluating new process developments, tracking progress toward performance targets, and facilitating energy use comparisons.

Climate VISION

The Industrial Technologies Program (ITP) is working in partnership with the Aluminum Association and its participating members of the Voluntary Aluminum Industry Partnership (VAIP) to implement activities in support of the Association's Climate VISION commitment. The Aluminum Association and VAIP have committed to a 53 percent carbon intensity reduction from 1990 levels through reduced emissions of per fluorocarbons (PFCs) and reduced consumption of the carbon anode from the primary aluminum reduction process. The industry has been working to reduce greenhouse gas emissions for over a decade and this new commitment equates to an additional carbon-intensity reduction of 25 percent since 2000. As a large industrial energy consumer, the primary producers also agree to continue their efforts to reduce CO₂ emissions through continued energy efficiency improvements (see Climate VISION Web site - www.climatevision.gov).

INDUSTRY OVERVIEW

Aluminum’s unique properties make it essential to modern manufacturing. The aluminum market after 100 years is still in the growth phase as aluminum metal finds new uses and replaces other materials. The industry over the past 10 years has been growing at an annual rate of 3.6 percent. The United States per capita consumption in 2000 was 78 pounds. The U.S. aluminum industry is the world’s largest, with manufacturing operations in more than 400 plants in 41 states and employing over 143,000 people. Demand for aluminum is increasing, mainly due to aluminum substitution for other materials in the transportation sector and other light weighting applications. Its low density, corrosion resistance, and easy processing possibilities, coupled with its ease and value for recycling, strengthen its position as the material of choice in many applications. Measured in either mass-produced or economic value, aluminum’s use exceeds that of any other metal except iron. It is important in virtually all segments of manufacturing. Exhibit 1 illustrates the wide use of aluminum and major U.S. industrial markets for aluminum components.

Aluminum Industry in Brief

Aluminum metal is made from two sources: primary metal produced from ore and secondary metal produced from scrap. The U.S. demand for aluminum metal is supplied by primary and secondary metal markets and by imports. Currently, these markets are of approximately equal size, each supplying about one-third of the demand.

Primary aluminum is made from alumina refined from bauxite ore. Primary aluminum is one of the most energy-intensive manufacturing processes. The alumina reduction to aluminum metal requires very large facilities (capacity over 400,000 tonnes/year) to obtain viable economies-of-scale. The large-scale and high-capital cost requirements (\$4,000/annual tonne) limit market entry. Only 11 producers operate 23 U.S. plants. These plants produced more than 2,636,500 tonnes of primary metal in 2001.¹

Since the inception of the industry, the United States has historically been the largest producer of primary aluminum. During the summer of 2001, the extensive heat wave in the western United States produced a dramatic increase in demand for electricity. Simultaneously, the ability to generate hydroelectric power was reduced due to historically low water levels in the Pacific Northwest. This combination of events contributed to significant increases in the price of electricity, which made it more economical for Pacific Northwest aluminum smelters to stop production and sell back their low-cost, fixed-price electricity contracts. As a result, the majority of aluminum smelting capacity in the Pacific Northwest, representing approximately 43 percent of all U.S. primary capacity, shut down. There has been a small but steady increase in production in 2002 as some of the Pacific Northwest capacity began to come back on-line. Although production decreased in 2001, plant capacity actually increased by 2.5 percent from 2000 to 2001.

Secondary aluminum is made from recycled aluminum products. The growth of secondary metal production represents the greatest change in the structure of the industry. Secondary metal, which accounted for 18 percent of U.S. aluminum metal production in 1960, in 2001 accounted for 53 percent. Recovering aluminum from scrap consumes less than 6 percent of the energy required to produce primary aluminum and capital costs are roughly one-tenth that of a primary plant. The economies-of-scale and barriers to market entry for secondary producers are less significant than in primary production. The United States has more than 91 plants in over 23 states that produced over 2,982,000 tonnes of metal in 2001. The U.S. secondary market will continue its strong growth (4.3 percent annually - 1990 to 2000) and be a major contributor to the industry’s energy savings.²

Exhibit 1
U.S. Aluminum Major Markets in 2001

Markets	Metric Tonnes	Percent
Transportation	3,015,000	31%
Containers & Packaging	2,200,000	23%
Buidling & Construction	1,313,000	13%
Consumer Durables	655,000	7%
Electrical	617,000	6%
Machinery & Equipment	589,000	6%
Other Shipments	247,000	3%
Exports	1,105,000	11%
Total	9,741,000	100%

Source: *Aluminum Statistical Review for 2001*, The Aluminum Association, page 23.

¹ Choate, William T. and John A.S. Green, PhD, *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*, November 2002, Appendix G. http://www.oit.doe.gov/aluminum/pdfs/al_theoretical.pdf

² Ibid, pg. 59.

The aluminum forming industry is comprised of over 300 facilities that transform metal into plate, sheet, foil, extrusions, and cast components that are used throughout the U.S. manufacturing industries.

Shipments and Trade

The aluminum industry's raw materials and product markets are global. The U.S. aluminum industry shipped over 9,741,000 metric tonnes of metal and produced over \$39 billion in products in 2001. This was a 1,370,000 metric tonne decrease compared to 2000.³

This decrease was due to electricity curtailments in the Pacific Northwest and a slowing of the U.S. economy in 2001. This slowdown caused the United States to drop in rank from its historical position as the largest producer of primary metal to the third-largest. Exhibit 2 illustrates the U.S. primary and secondary production along with total U.S. shipments over the last 5 years.

Exhibit 3 illustrates the U.S. market share as a percentage of world primary production over the last 5 years. It is important to note that many U.S. aluminum companies maintain production facilities in other countries around the world. Global primary aluminum production has been growing at a rate of 2.2 percent annually over the last 10 years.

Global restructuring of the primary aluminum industry began in the late 1970s and continues to this day. Since energy costs are approximately one-quarter to one-third of the total cost of primary aluminum, many companies have moved production from sites close to consumer markets to sites with low electricity costs. Nearly 53 percent of the energy used worldwide for primary aluminum production comes from hydroelectric power.⁴ Australia and Canada have emerged as major primary metal producers; other countries entering the world market include Brazil, China, Norway, Venezuela, and countries in the Persian Gulf area, all areas with low-cost electric energy cost.

Secondary aluminum is produced by melting and purifying scrap or recycled aluminum. Fifty-three percent of the domestically produced aluminum in the United States is made from recycled aluminum scrap. Aluminum recycling is concentrated in the countries where the scrap is generated with the exception of a few Asian countries that import significant amounts of aluminum scrap due to the demand in their automobile industries. Worldwide, secondary aluminum production is roughly one-quarter of total aluminum production. Detailed world secondary aluminum production numbers are not available.

Imported aluminum supplies the U.S. demand for metal that is not met by local production. Imports are used to manufacture nearly one-third of the aluminum products produced in the United States. Exhibit 4 lists the five countries that provide most of the U.S. imported aluminum. Canada is the largest exporter, followed by Russia. Imports typically originate from countries with large hydroelectric capacity and low-cost electricity.

Exhibit 2
U.S. Aluminum Production

Year	U.S. Primary Metal Production, Metric Tonnes	U.S. Secondary Metal Production, Metric Tonnes	U.S. Industry Shipments, Metric Tonnes
1997	3,603,400	3,547,000	10,212,000
1998	3,712,700	3,442,000	10,519,000
1999	3,778,600	3,695,000	11,188,000
2000	3,668,400	3,450,000	11,111,000
2001	2,636,500	2,982,000	9,741,000

Source: *Aluminum Statistical Review for 2001*, The Aluminum Association.

Exhibit 3
World Primary Production

Year	Global Primary Metal Production, Metric Tonnes	U.S. Global Market Share, %
1997	21,703,000	16.6%
1998	22,608,000	16.4%
1999	23,643,000	16.0%
2000	24,397,000	15.0%
2001	24,353,000	10.8%

Source: *Aluminum Statistical Review for 2001*, The Aluminum Association, page 43.

Exhibit 4
U.S. Imports by Country in 2001

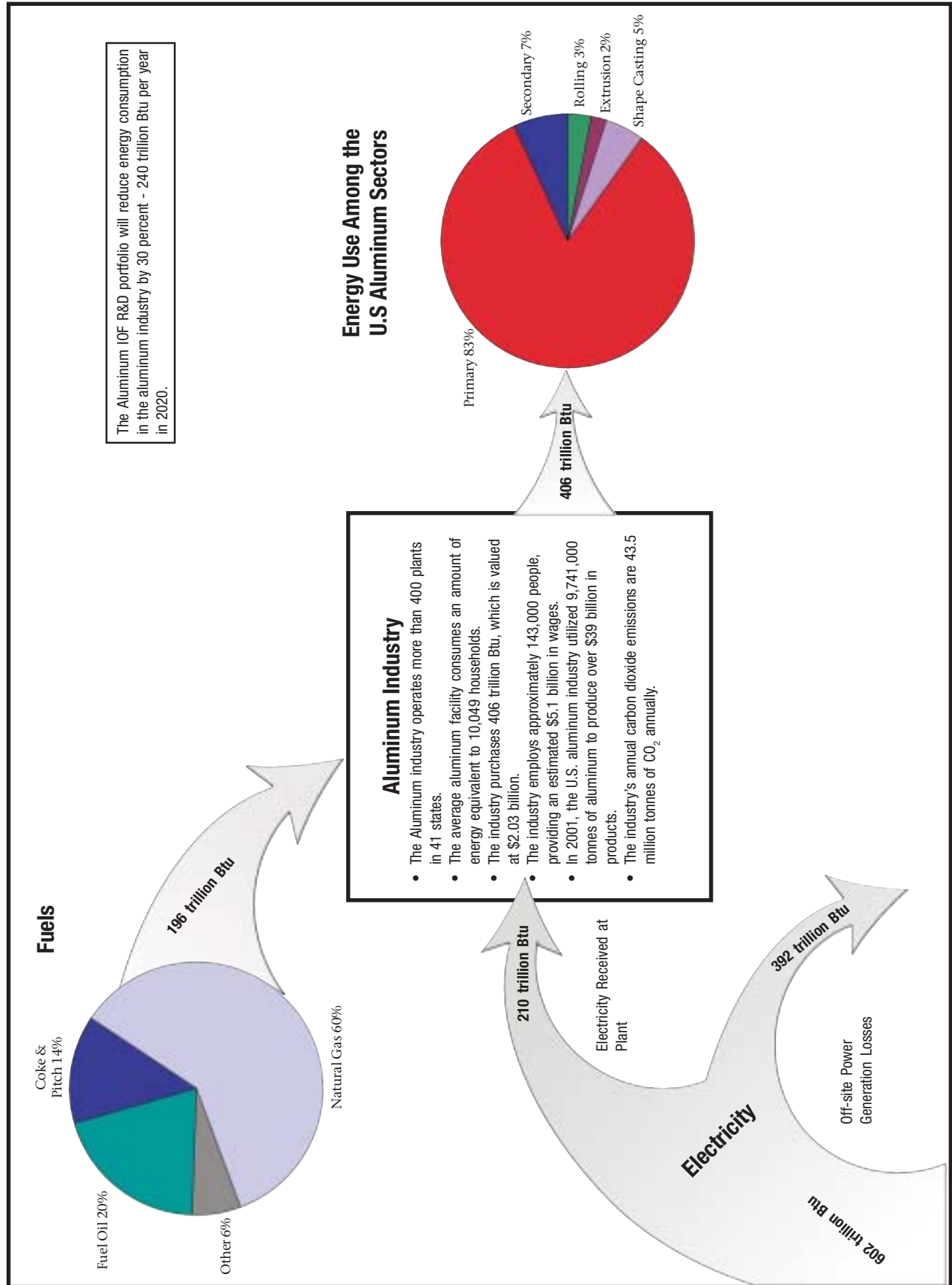
Country	Metric Tonnes	Percent of Imports
Canada	2,508,000	62.5%
Russia	481,700	12.0%
Venezuela	189,000	4.7%
Australia	123,100	3.1%
Germany	98,350	2.5%

Source: *Aluminum Statistical Review for 2001*, The Aluminum Association, page 36.

³ Aluminum Association: www.aluminum.org.

⁴ Choate, William T. and John A.S. Green, PhD, *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*, November 2002, Appendix D-Table D-2.

Exhibit 5 Energy Use in the Aluminum Industry



THE CHALLENGE

The U.S. aluminum industry has reduced its energy intensity by 58 percent over the past forty years, 21 percent as a result of technical progress and 37 percent with the growth of recycling. Secondary aluminum's strong growth rate (4.3 percent annually) will continue to contribute strongly in lowering the total energy demand of the industry. It is also changing the structure of the industry. Its inherently low energy intensity (6 percent of primary metal) and lower capital requirements have made secondary metal the largest production segment for aluminum in the United States.

All commercial primary aluminum (aluminum from ore) is produced using one process, Hall-Héroult electrolytic reduction of alumina developed and patented in 1886. This process consists of a reaction cell with electrodes. Though the engineering has improved vastly in efficiency and scale, the process fundamentals are unchanged. The Hall-Héroult process is electric energy-intensive and electricity costs are an important portion (about one-half) of the total production costs. Energy efficiency has been a major area of focus for the primary sector and significant engineering changes in cell design and operation have occurred. Technical progress of late has been slow and incremental. The last significant energy efficiency process improvement, new equipment and techniques for smaller and more frequent alumina additions, began in the 1970s. Future technologies with significant energy efficiency gains to the Hall-Héroult process are both high-risk and research-intensive.

The energy consumed in 2000 by the U.S. primary aluminum industry was over three times greater than the theoretical minimum requirement. This large difference is a measure of the technical potential to reduce energy intensity by R&D activities. Realistically, however, technically achievable cost-effective energy savings are much smaller than the difference between theoretical and practice, but still very large and significant. Examining the energy consumption and theoretical requirements for individual processes reveals the pathways where valuable R&D resources should be focused to provide the greatest reduction of energy intensity.

Primary metal production consumes an order-of-magnitude more energy than secondary production. It would appear that the most significant energy-saving opportunities would come from work in primary metal technologies. But significant overall industry energy savings will come from focused R&D efforts in both primary and secondary metal technologies. Any technology that aids in recovering aluminum (e.g., identifying and sorting scrap) or technology that reduces the oxidation of aluminum and dross losses in secondary metal production furnaces is in effect saving nearly all the energy that was required to produce the primary metal. Approximately, recovering one additional pound of secondary aluminum saves ten times the energy required to produce the same pound of metal with primary processing. The secondary metal industry is dominated by small companies that do not have the resources to focus on R&D such as high-risk melting/thermal technologies.

Research Categories of the Aluminum IOF

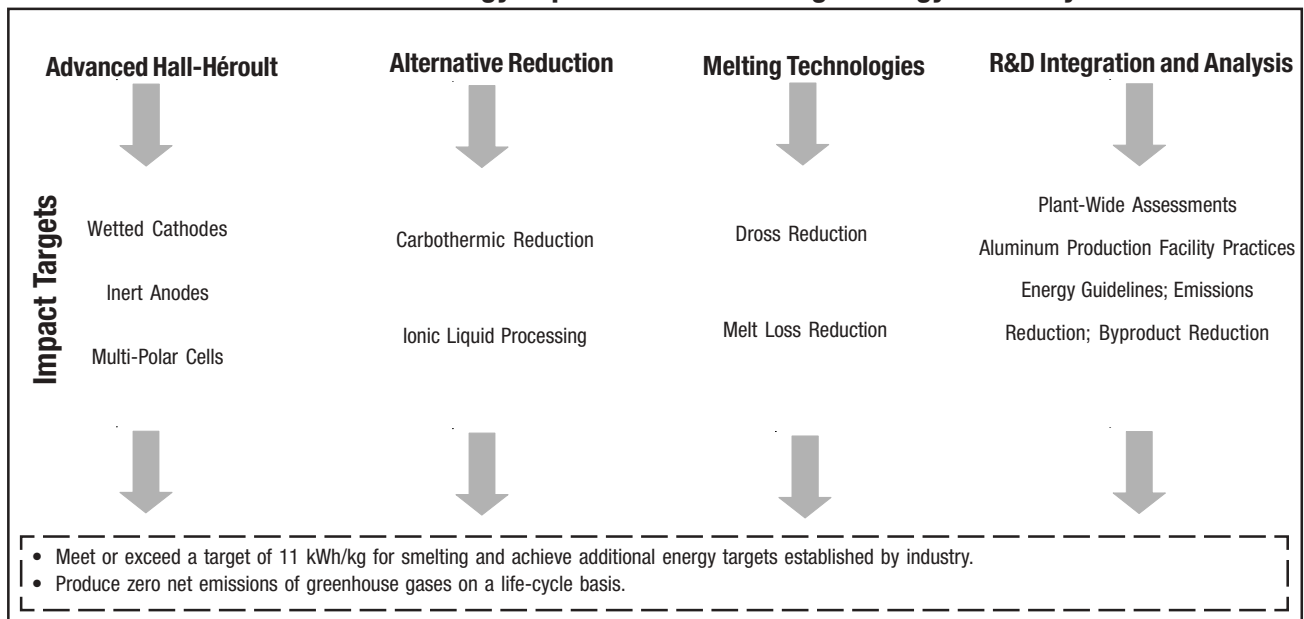
The success of the Aluminum IOF is the result of a strong partnership between the aluminum industry, its suppliers, academia, national laboratories, and EERE. This partnership directs its efforts at high-impact, revolutionary research to improve energy efficiency and to lower emissions. The research is grouped into four categories:

- **Advanced Hall-Héroult Cells:** Research to develop materials and engineering designs needed to dramatically reduce unproductive heat-generating cell resistances, eliminate cell-side CO₂ emissions with inert anode materials, and provide more efficient control of cell fluid flows.
- **Alternative Reduction Systems:** Research to develop non-Hall-Héroult reduction techniques that have the ability to revolutionize the aluminum industry.
- **Melting/Thermal Technologies:** Research that focuses on the entire melting/thermal system and involves multiple technologies that minimize melt oxidation, dross formation, and remelting

requirements. Improvements in the melting process will have a very large impact on energy consumption and costs.

- **R&D Integration and System Analysis:** Integration of applicable ITP technologies for improving energy efficiency and reducing emissions in aluminum manufacturing practices. This includes other IOF portfolios and ITP's BestPractices programs for energy-demand management.

Exhibit 6
Process & Technology Improvements That Target Energy Efficiency



FY 2003 HIGHLIGHTS & ACCOMPLISHMENTS

The Aluminum Industry of the Future (IOF) supports a diverse and balanced R&D portfolio of cost-shared, pre-competitive projects that will help realize national goals in energy, competitiveness, and the environment. The 31 active projects within the FY 2003 portfolio have a total budget of \$62 million, \$32 million in Aluminum IOF funding, and \$30 million in cost-share funding from the project partners.

All R&D projects are selected through a competitive solicitation process. Official solicitation notices can be found on the Aluminum IOF Web site, *Commerce Business Daily*, and/or *FedBizOpps*. Projects are chosen on the basis of energy saved, environmental improvements, and the industry needs identified in vision and roadmap documents. Awarded projects are researched by multi-team partnerships and typically include at least one aluminum company or industry equipment supplier to boost the market introduction phase of commercial development. The Aluminum IOF maintains a balanced R&D portfolio by performing annual portfolio reviews in which industry experts assess the current status of projects in terms of energy savings and industry impact. These experts recommend to the Aluminum IOF and principal investigators modifications to projects to ensure that projects meet milestones and the program meets its goals. The Aluminum Association plays an active role in supporting, monitoring, and disseminating project results and Aluminum IOF activities.

Broad Industry Participation

The Aluminum IOF requires R&D project partnerships among industry, suppliers, universities, and national laboratory participants. Partnerships spread the cost and risk of R&D, enabling and accelerating work on projects too complex, costly, or time-consuming for individual companies to undertake themselves. The involvement of the industry partners in the early stages of R&D accelerates technology transfer and dissemination of research results. Partnerships bring together technical expertise, practical experience, and state-of-the-art resources and facilities to dramatically accelerate advances in critical challenge areas.

The FY 2003 Aluminum IOF portfolio funded 31 active projects with 69 industry, laboratory, and university partners in 23 states. Exhibit 7 illustrates the funding distribution of Aluminum IOF funding by performing organization. Industry received 64 percent, national laboratories received 27 percent, and universities received 9 percent of the IOF project funding. The geographic reach of the Aluminum IOF partnership is illustrated in Exhibit 8 (page 7) and includes suppliers, designers, manufacturers, end-users, and national laboratories. The IOF portfolio also enables the industry to expose students to opportunities in the aluminum industry by involving universities in various research projects.

Exhibit 7
Aluminum IOF Funding
by Performing Organization

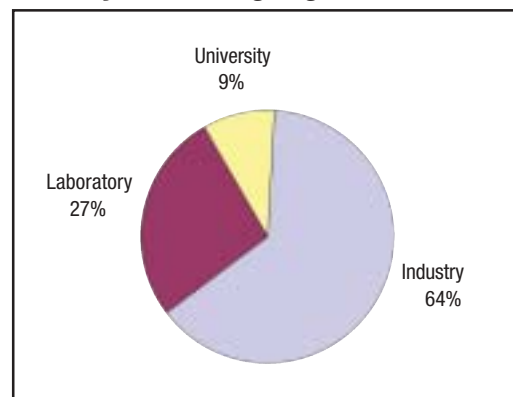
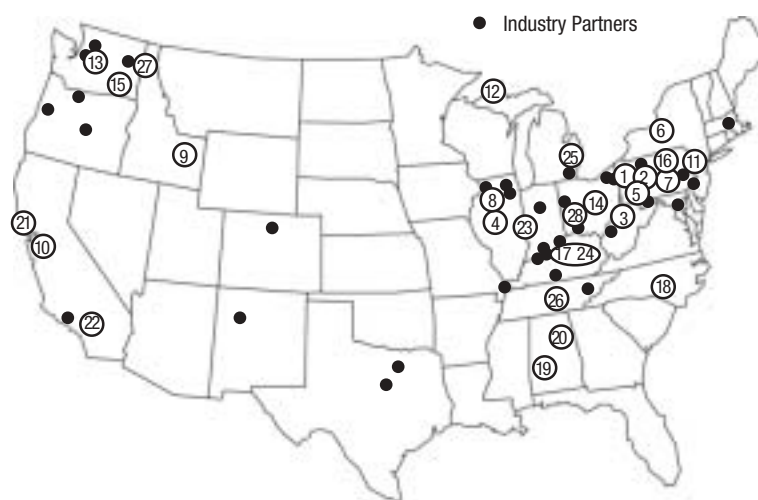


Exhibit 8 Industry Partnership Aluminum Research Performers and Project Partners

Primary Research Performers	
1	Alcoa Incorporated
2	Apogee Technology, Inc.
3	Applied Industrial Solutions, LLC
4	Argonne National Laboratory
5	Carnegie Mellon University
6	Cornell University
7	EMEC Consultants
8	Gas Technology Institute
9	Idaho National Engineering and Environmental Laboratory
10	Lawrence Livermore National Laboratory
11	Lehigh University
12	Michigan Technological University
13	Northwest Aluminum Technologies
14	Ohio State University
15	Pacific Northwest National Laboratory
16	Pennsylvania State University
17	Secat, Inc.
18	Selee Corporation
19	University of Alabama
20	University of Alabama-Birmingham
21	University of California-Berkeley
22	University of California-Irving
23	University of Illinois at Urbana-Champaign
24	University of Kentucky
25	University of Michigan
26	University of Tennessee
27	Washington State University
28	Wright State University



The Aluminum Industry of the Future is partnering with 69 university, industry, and laboratory partners in 23 states across the U.S.

A Diverse Research Portfolio

Exhibit 9 illustrates Aluminum IOF funding by research category. The portfolio addresses the diversity of the industry with research in melting/thermal, forming, and primary operations. The largest opportunities for improving energy efficiency are in the primary production sector and the largest portion of the funding goes to research in this area. A list of the current portfolio of aluminum projects along with performing organizations organized by these categories is shown in Exhibit 10 (page 8).

Integrated Technical Assistance for the Aluminum Industry

ITP has strategically designed its organizational structure to provide industry with an integrated array of assistance for saving energy.

A number of other EERE portfolios have performed research related to the aluminum industry. These include EERE's NICE³ and Inventions & Innovation and ITP's Steel and Metal Casting IOFs, Sensors and Controls, and Supporting Industries. Combined, these portfolios have performed approximately \$25 million in additional research and technical assistance relevant to the aluminum industry.

Beyond the research funding provided by the Aluminum IOF, many EERE technical and financial assistance resources and services are available to improve energy efficiency and increase competitiveness in the aluminum industry. Several examples of EERE assistance are shown in Exhibit 11. Exhibit 12 lists recent examples of research above and beyond that performed through the Aluminum IOF that is relevant to the aluminum industry.

Exhibit 9 Research Funding by Roadmap Category

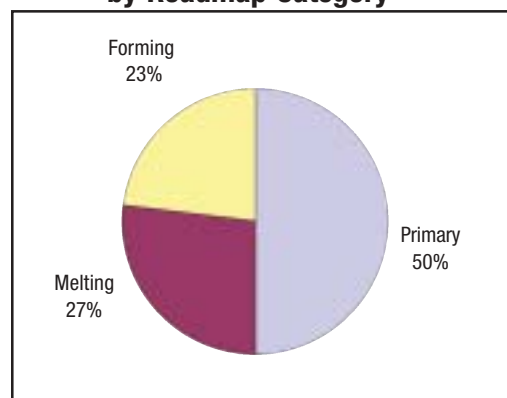


Exhibit 10

Aluminum Portfolio by Primary Category and Project Leadership

(Fact sheets are available at <http://www.oit.doe.gov/aluminum/portfolio.shtml>)

Primary

Advanced Hall-Héroult

- Intelligent Potroom Operation (*Applied Industrial Solutions LLC*)
- Inert Metal Anodes for Primary Aluminum Production (*Argonne National Laboratory*)
- Potlining Additives (*EMEC Consultants*)
- Microwave-Assisted Electrolyte Cell with Inert Anode and Wetted Cathode for Primary Aluminum Production (*Michigan Technological University*)
- Inert Metal Anode Life in Low Temperature Aluminum Reduction (*Northwest Aluminum Technologies*)
- Numerical Modeling of Transient Melt Flows and Interface Instability in Aluminum Reduction Cells (*University of Michigan*)

Alternative Reduction Technologies

- Aluminum Carbothermic Technology (*Alcoa Incorporated*)
- Low-Temperature Reduction of Alumina Using Fluorine Containing Ionic Liquids (*University of Alabama*)

Melting

- Energy Efficient Isothermal Melting (ITM) of Aluminum (*Apogee Technology, Incorporated*)
- Spray Rolling Aluminum Strip (*University of California-Irvine*)
- High-Efficiency Low-Dross Combustion System for Reverberatory Furnaces (*Gas Technology Institute*)
- Molten Aluminum Treatment by Salt Fluxing with Low Environmental Emission (*Ohio State University*)
- Improving Energy Efficiency in Aluminum Melting (*Secat, Incorporated*)
- Modeling Optimization of Direct Chill Casting to Reduce Ingot Cracking (*Secat, Incorporated*)
- Reduction of Oxidative Melt Loss (*Secat, Incorporated*)
- Selective Adsorption (*Selee Corporation*)
- Gas Fluxing of Aluminum (*University of California Berkeley*)
- Degassing of Aluminum Alloys Using Ultrasonic Vibrations (*University of Tennessee*)

Forming

- Combined Experimental and Computational Approach for the Design of Mold Surface Topography (*Cornell University*)
- Coolant Characteristic and Control in Direct Chill Casting Aluminum (*Idaho National Engineering and Environmental Laboratory*)
- Development of a Rolling Process Design Tool for Use in Improving Hot Roll Slab Recovery (*Lawrence Livermore National Laboratory*)
- Surface Behavior of Aluminum Alloys Deformed Under Various Processing Conditions (*Lehigh University*)
- Energy-Efficient Manufacturing of Superior Aluminum Extrusions (*Pacific Northwest National Laboratory*)
- Effects of Impurities on the Processing of Aluminum Alloys (*Pennsylvania State University*)
- Evaluation & Characterization of In-Lined Annealed Continuous Cast Aluminum Sheet (*Secat, Incorporated*)
- Effects of Casting Conditions and Composition on Microstructural Gradients in Roll Cast Aluminum Alloys (*University of Alabama-Birmingham*)
- Reduction of Annealing Times for Energy Conservation in Aluminum Processing (*Carnegie Mellon University*)
- Two-Phase Model for the Hot Deformation of High-Alloyed Aluminum (*University of Illinois-Urbana*)
- Structural Factors Affecting Formability of Continuous Cast Aluminum Alloys (*University of Kentucky*)
- Development of Integrated Methodology for Thermo-Mechanical Processing of Al Alloys (*Washington State University*)
- Continuous Severe Plastic Deformation Processing of Aluminum Alloys (*Wright State University*)

In addition to the portfolios listed in Exhibit 11, EERE provides research on leading-edge enabling technologies, including Sensors & Controls, Industrial Materials, Combustion, and Forging. These areas operate on the IOF model of risk sharing on industry-specific, pre-competitive, long-term, high-impact research. The IOF provides financial assistance for small businesses through Small Business Innovative Research (SBIR) grants.

The Aluminum IOF is working with Allied Partners to help deploy the results of aluminum research and improve energy efficiency in the industry. Allied Partners are manufacturers, trade associations, industrial service and equipment providers, utilities, and other organizations that agree to help promote and increase energy efficiency and increase productivity of industries that participate in the Industries of the Future strategy. The Aluminum IOF completed two new Allied Partnership agreements in FY 2003 with Secat, Incorporated, and the Aluminum Association. Through these Allied Partners, the Aluminum IOF is able to more widely disseminate the results of research programs and technical assistance.

Exhibit 11 Examples of EERE Technical and Financial Assistance

- **NICE³:** National Industry Competitiveness through Energy, Environment, and Economics (NICE³) provides funding to state and industry partnerships (large and small businesses) for projects that develop and demonstrate advances in energy efficiency and clean production technologies.
- **I&I:** Inventions and Innovation (I&I) provides financial assistance for conducting early development and establishing technical performance of innovative, energy-saving ideas and inventions.
- **IAC:** Industrial Assessment Centers enable eligible small and medium-sized manufacturers to receive comprehensive industrial assessments—performed at no cost to the manufacturer.
- **Plant-Wide Assessments:** Plant-wide energy assessments investigate overall energy use in industrial facilities—which can account for 10 percent or more of an industry's total operating costs—and highlight opportunities for best energy management practices for industry, including the adoption of new, efficient technologies.

Exhibit 12

Examples of EERE and ITP Research Related to Aluminum

Financial Assistance

- Aluminum Bridge Decking (NICE³)
- Aluminum Scrap Decoater (NICE³)
- Demonstration of a High-Temperature, Corrosion-Resistant Recuperator for the Metals Industry (NICE³)
- Energy Conserving Tool for Combustion Dependent Industries (NICE³)
- Increasing Productivity and Reducing Emissions Through the Enhanced Application Control Die Casting Lubricants (NICE³)
- Microsmooth Process on Aluminum Wheels (NICE³)
- Rapid Heat Treatment of Cast Aluminum Components (NICE³)
- Recycling of Aluminum Dross/Saltcake (NICE³)
- Advanced Intermetallic Alloy Development (I&I)
- Lightweight Cost Effective Cast Aluminum Diesel Engine Head with Localized Reinforcement (I&I)
- CFCC Immersion Tubes (I&I)
- Nickel Aluminide Heat Trays and Furnace Fixtures (I&I)
- Brazing and Spot Welding Innovations for Joining Aluminum Compounds (I&I)
- Development of a Composite Reinforced Aluminum Conductor (I&I)
- Development of an Innovative Energy Efficient High Temperature Natural Gas Fired Furnace (I&I)
- Development of Inert Anode for Primary Aluminum Industry (I&I)
- Energy Saving Lightweight Refractory (I&I)
- Filtering Molten Metal (I&I)
- Innovative System Blows Away Sorting Problems for Recyclers (I&I)
- Monolithic Refractory Material (I&I)
- Nickel Based Superalloy with Improved Oxidation Resistance (I&I)
- Novel Ceramic Composition for Hall-Heroult Cell Anode Technologies (I&I)
- Viable Inert Cathode for Smelting Primary Aluminum (I&I)
- Novel Technique for Increasing Corrosion Resistance (I&I)
- Reflective Aluminum Chips (I&I)
- Titanium Matrix Composites Tooling Material for Enhanced Manufacture of Aluminum Die Castings (I&I)
- Viable Inert Cathode for Smelting Primary Aluminum (I&I)

Crosscutting Applications

- Forced Internal Reticulation (FIR) Burner (Combustion)
- Dynamic Expert System Controls for Optimum Oxyfuel Melter Performance (Glass)
- Advanced Lost Foam Casting Technology (Metal Casting)
- Development of Natural Aging Aluminum Alloy (Metal Casting)
- Die Materials for Critical Applications and Increased Production Rates (Metal Casting)
- Gating of Aluminum Permanent Mold Castings (Metal Casting)
- Heat Transfer at the Mold/Metal Interface in Permanent Mold Castings of Aluminum Alloys (Metal Casting)
- Metallic Reinforcement of Direct Squeeze Die Cast Aluminum Alloys for Improved Strength and Fracture (Metal Casting)
- Optimization of the Squeeze Casting Process for Aluminum Alloy Parts (Metal Casting)
- Sensors for Die Casting (Metal Casting)
- Effects of Applied Pressure During Feeding on the Fatigue Properties of Cast Aluminum Alloys (Metal Casting)
- Rotary Burner Demonstration (Petroleum)
- Centrifugally Cast Nickel Aluminide Transfer Rolls for Steel (Steel)
- Laser Ultrasonics for On-Line Measurement of Tube Wall and Eccentricity (Steel)
- Measurements of Melt Constituents with LIBS (Steel)
- No_x Emissions Reduction by Oscillating Combustion (Steel)
- Intelligent Extruder (Sensors and Controls)
- Thermal Imaging Control of Furnaces and Combusters (Sensors & Controls)
- Enhancement of Aluminum Alloy Forging (Supporting Industries)
- Materials and Process Design for High Temperature Carburizing (Supporting Industries)
- Innovative Die Material and Lubrication Strategies for Forging Technologies (Supporting Industries)
- Integrated Heat Treatment Model for Aluminum Castings (Supporting Industries)

Technical Assistance

- BestPractices - Plant Assessments and Hands-on Technical Assistance
 - Alcoa
 - Amcast
 - Alumax
 - Metlab
- Industrial Assessments
 - Over \$20 million in annual energy-saving recommendations implemented in the Aluminum industry since 1992

The Aluminum Industry of the Future achieved a number of important accomplishments in FY 2003 with energy efficiency improvements to be transferred to and applied by the aluminum industry. The following describes accomplishments in several key areas:

- Applying R&D Results
- Partnership Highlights
- Disseminating Research Results to Industry
- Energy Analysis

Applying R&D Results

The aluminum industry is using Aluminum IOF research results to improve their energy efficiency and lower their costs. The following list provides examples of current Aluminum IOF projects that are displaying promising results, those R&D projects that are emerging into commercial applications, and those commercially implemented in the aluminum industry.

Current R&D with Promising Results

- **Inert Metal Anode for Low-Temperature Aluminum Reduction Processes** – Researchers from Northwest Aluminum Technologies have developed and are conducting tests of a multipolar cell concept that operates the Hall-Héroult process 200°C with no on-site CO₂ emissions. This technology will enable primary production of metal with lower energy intensity, cost, and environmental impact when compared to modern Hall-Héroult cells. The research has had promising results in a 300-ampere cell and work is now progressing to tests in a 5,000-ampere cell. ITP estimates an energy savings of 19.2 trillion Btu and an energy cost savings of \$108.3 million in 2020 for this project. To learn more, please visit www.oit.doe.gov/aluminum/factsheets/advcells.pdf.
- **Intelligent Potroom Operations** – A team led by Applied Industrial Solutions, LLC, has been working to improve the efficiency of Hall-Héroult operations using a new process control approach “Intelligent Potroom Operation.” This computer application is based on using real-time data collection, analysis, and process modeling to optimize cell parameters. Optimization allows cells to be operated at higher current efficiencies, saving energy and avoiding cell disruption. ITP estimates an energy savings of 400 million Btu and an energy cost savings of \$2.2 million in 2020 for this project. To learn more, please visit www.oit.doe.gov/aluminum/factsheets/potroomoperation.pdf.
- **Aluminum Carbothermic Technology** – The carbothermic process is a complex, high-temperature (>2,000°C), three-stage thermodynamic reaction system for producing primary aluminum. Researchers led by Alcoa, Incorporated, are demonstrating the technical, economic, and environmental viability of this alternative to Hall-Héroult technology. The technology will reduce the energy, capital, and environmental cost of producing aluminum. Research on the individual stages will be complete in early 2004. ITP estimates an energy savings of 10.0 trillion Btu and an energy cost savings of \$56.4 million in 2020 for this project. To learn more, please visit www.oit.doe.gov/aluminum/factsheets/actarp.pdf.
- **Reduction of Oxidative Melt Loss** – During melting and furnace holding operations, as much as 8 percent of the molten aluminum is lost to oxidation of the metal at the surface of the molten pool. This represents a loss of all the primary metal energy inputs as the metal reverts back to alumina. Researchers led by Secat, Incorporated, are developing a methodology to reduce melt loss/oxidation by 50 percent. The researchers analyzed melt loss mechanisms and, from this knowledge, identified and evaluated potential concepts for reducing the loss. Two concepts were selected for further evaluation and development: boron nitride plates/tile and the use of boric acid to cover the molten metal surface. The results of this project will apply throughout the aluminum industry and may apply in other industries. ITP estimates an energy savings of 11.2 trillion Btu and an energy cost savings of \$37.1 million in 2020 for this project. To learn more, please visit www.oit.doe.gov/aluminum/factsheets/meltlossreduction.pdf.
- **Evaluation & Characterization of In-Lined Annealed Continuous Cast Aluminum Sheet:** Researchers led by Secat, Incorporated, are developing an optimized, energy-efficient thermo-mechanical processing procedure for in-line annealing of continuously cast hot strips. Continuous casting saves more than 25 percent of the energy consumed by traditional rolling and annealing of large ingots. The research team

has successfully designed, built, and installed an in-line induction heating system at a commercial continuous casting facility. This project will enable the expansion of continuous casting technology by making the process applicable to a wider range of alloys. ITP estimates an energy savings of 3.4 trillion Btu and an energy cost savings of \$15.8 million in 2020 for this project. To learn more, please visit www.oit.doe.gov/aluminum/factsheets/in-lineannealed.pdf.

The Aluminum IOF reviews its portfolio to identify those technologies that are emerging as potential commercial successes or are having commercial success. “Emerging” technologies are those technologies that have achieved laboratory or pilot-scale successes and are ready to be deployed on a commercial scale. Industry of the Future “commercial” technologies are those currently being used in the commercial industry as a result of IOF funding. The following list provides examples of these commercial and emerging technologies.

Emerging Technologies

- **The Vertical Flotation Melter** - Energy Research Company and other industrial partners designed, built, and tested an innovative Vertical Flotation Melter (VFM) for processing scrap aluminum. The VFM can decoat aluminum scrap for feeding into a conventional furnace, or it can simultaneously decoat and melt scrap, which is a unique accomplishment. The thermal efficiency of the integrated decoat/melt process is estimated to be over 75 percent. The emissions of NO_x, SO₂, CO, and VOCs from the VFM process have been measured to be well below allowable limits. The VFM has demonstrated a 58 percent thermal efficiency melting. It is estimated to provide potential U.S. energy savings of 17 trillion Btu. To learn more about this project, visit www.oit.doe.gov/aluminum/factsheets/floatation.pdf.

Commercial Technologies

- **Oxygen Enhanced Combustion** - A research team led by Air Products & Chemicals, Incorporated, has developed and demonstrated a high-efficiency, high-capacity, low-NO_x combustion system integrated with an innovative, low-cost, vacuum-swing-adsorption oxygen system. This system uses a novel air-oxygen-natural gas burner that provides 30 percent higher furnace productivity and 40 percent energy efficiency improvements with low NO_x emissions relative to air-fuel burners. Presently, this system has been permanently installed into a commercial furnace. To learn more about the project, view the final report at www.oit.doe.gov/aluminum/pdfs/oxygenenhancedcombustion.pdf.
- **Detection and Removal of Molten Salts from Molten Aluminum Alloys** - A research team led by Selee Corporation developed a new probe and filter technology for detecting and absorbing molten salts and removing particulates from molten aluminum alloys. This new technology increases casting yields by lowering the defect rate. Higher casting yields mean that less metal needs to be remelted, lost to oxidation and dross, and processed. It is estimated that this technology will have an annual energy savings of 40 billion Btu. To learn more about this project please view the final report at www.oit.doe.gov/aluminum/pdfs/detectionandremoval.pdf.

Partnership Highlights

Aluminum Industry Technology Roadmap - In 2001, the North American aluminum industry published its new vision, *Aluminum Industry Vision: Sustainable Solutions for a Dynamic World*. In February 2003, the aluminum industry updated the *Aluminum Industry Technology Roadmap* to define the specific research and development (R&D) priorities, performance targets, and milestones required to achieve that vision. The document focuses on three areas: Products and Markets, Sustainability, and Energy and Resources. To learn more about this roadmap or to receive a copy, visit www.oit.doe.gov/aluminum/tools.shtml.

Disseminating Research Results

The Aluminum Industry of the Future (IOF) performs outreach activities to disseminate R&D results, promote emerging technologies and provide information on how to get involved in IOF activities. These activities include participating in conferences, seminars, trade shows, and maintaining an up-to-date Web site that highlights Aluminum IOF activities. Examples of FY 2003 outreach activities include the following:

- **The Minerals, Metals, and Materials Society (TMS) Annual Meetings** - In March 2-6, 2003, TMS hosted its 132nd Annual Meeting and Exhibition in San Diego, California. This is the largest gathering of aluminum technologists in the United States. The Aluminum IOF projects were well represented with 11 papers directly related to the portfolio presented. In addition, three programmatic papers were also presented: *Partnership Opportunities with the DOE-EERE Industrial Technologies Program*, *Aluminum Technology Roadmap*, and *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*.
- **2003 American Council for Energy Efficient Economy (ACEEE) Industrial Summer Study** - From July 29 through August 1, 2003, in Rye Town, New York, ACEEE held its 2003 Summer Study. Representatives from the Aluminum IOF gave a presentation on the challenges to life cycle analysis, *U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*.

Energy Analysis - Targeting Energy Efficiency

Aluminum Processing Energy Benchmark - The Aluminum Industry of the Future performed an in-depth analysis of energy use in the aluminum industry to identify energy-intensive processes and technologies and to determine where major energy savings can be achieved. The result of this analysis is presented in the report, *U.S. Energy Requirement for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*. This report provides energy performance benchmarks for evaluating new process developments, tracking progress toward performance targets, and facilitating comparisons of energy use. The report provides a basic description of the processes and equipment involved, their interrelationship, their effects on the energy consumed, and the environmental impact of manufacturing aluminum and aluminum products. This knowledge can assist in identifying, understanding, and measuring process areas where significant energy reduction and environmental improvements can be made.

Climate VISION

On February 14, 2002, President Bush announced a new strategy to address the long-term challenge of global climate change. The President committed to reducing America's greenhouse gas intensity – the ratio of emissions to economic output – by 18 percent in the next decade, and challenged American businesses and industries to undertake broader efforts to help meet the goal. The President's strategy, known as Climate VISION (Voluntary Innovative Sector Initiative: Opportunities Now), is focused on voluntary partnerships between the government and entire industry sectors. These partnerships aim to reduce the projected growth in America's greenhouse gas emissions through research, development, and deployment of energy-saving technologies and processes.

The U.S. Department of Energy, along with other key Federal Agencies, recognizes that major, energy-intensive sectors of the American economy are undertaking significant initiatives to meet the President's challenge. These initiatives build upon the progress made by the industrial sector in the past decade: from 1990-2001. During this time, the economy grew by almost 40 percent, while greenhouse gas emissions in the industrial sector remained constant. The Industrial Technologies Program (ITP) is working in partnership with the Aluminum Association and its participating members of the Voluntary Aluminum Industry Partnership (VAIP) to implement activities in support of the Association's Climate VISION commitment. The Aluminum Association and VAIP have committed to a 53 percent carbon intensity reduction from 1990 levels through reduced emissions of per fluorocarbons (PFCs) and reduced consumption of the carbon anode from the primary aluminum reduction process. The industry has been working to reduce greenhouse gas emissions for over a decade and this new commitment equates to an additional carbon-intensity reduction of 25 percent since 2000. As a large industrial energy consumer, the primary producers also agree to continue their efforts to reduce CO₂ emissions through continued energy efficiency improvements (see Climate VISION Web site - www.climatevision.gov).

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

A large variety of software tools, publications, and other resources are provided to the industry by the Aluminum IOF and its partners. These items promote energy-efficient practices, provide information on new technologies, and inform the industry of activities provided by EERE.

Tools and Publications

The tools available from the Aluminum IOF include:

- ***Vision and Roadmaps*** - The industry's unified vision outlines broad goals for the aluminum industry's future. The roadmaps establish the aluminum industry's R&D priorities, performance targets, and milestones for attaining the vision goals. The roadmaps for the Aluminum IOF are:
 - Aluminum Technology Roadmap (2003)
 - Inert Anode Roadmap
 - Alumina Technology Roadmap
 - Aluminum Automotive Roadmap
- ***Energy and Environmental Profile of the Aluminum Industry*** - This report benchmarks the energy and environmental characteristics of the key technologies used in the major processes of the aluminum industry.
- ***U.S. Energy Requirements for Aluminum Production: Historical Perspective, Theoretical Limits, and New Opportunities*** - This report (2003) provides detailed appendices, statistical data, and descriptions of the fundamental chemistry as well as practical aspects of aluminum production processes. It compares current usage levels and theoretical minimum energy requirements to demonstrate that large energy saving opportunities exist.
- ***Inert Anode Report*** - This American Society of Mechanical Engineers report provides a broad assessment of open literature and patents that exist in the area of inert anodes and their related cathode systems and cell designs, technologies that are relevant for the advanced smelting of aluminum. The report also discusses the opportunities, barriers, and issues associated with these technologies from a technical, environmental, and economic viewpoint.
- ***Efficient Process Heating in the Aluminum Industry*** - This report (2003) provides suggestions for enhancing the energy efficiency of melters and furnaces to cut process-heating costs by 10 - 30 percent.

To view these documents and applications, please visit: www.oit.doe.gov/aluminum/tools.shtml.

Fact Sheets

The Aluminum IOF disseminates information on current and past projects through project fact sheets. The information provided in each fact sheet includes the objective, accomplishments, benefits, principal investigator, and project partners. All aluminum fact sheets are available on-line at: www.oit.doe.gov/aluminum/portfolio.shtml.

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at www.eere.energy.gov/industry.

- Collaborative, **cost-shared research and development** projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.
- **Industries of the Future Partnerships** increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.
- **Allied Partnerships** provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.
- **State energy organizations** work with ITP in applying technology to assist their local industries. ITP assists states in developing IOF partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.
- **EERE's technical programs** (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at www.eere.energy.gov.
- The President's **Climate VISION** (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers **energy management best practices** to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.
- Our suite of powerful system optimization **software tools** can help plants identify and analyze energy-saving opportunities in a variety of systems.
- **Training sessions** are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified **industrial energy specialists** will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.
- Our extensive library of **publications** gives companies the resources they need to achieve immediate energy savings.
- **Plant-wide energy assessments** are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.
- The **DOE Regional Offices** provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle. Visit www.eere.energy.gov/rso.html for more information.

Where to Go For More Information

Learn about all EERE programs - <http://www.eere.energy.gov/>

Ask an Expert - The Office of Industrial Technologies Clearinghouse is a great way to access ITP's resources. Times available are 9 a.m. to 8 p.m. EST (6 a.m. to 5 p.m. PST).
 Phone: 1-800-862-2086
 Fax: 360-956-2214
 E-mail: clearinghouse@ee.doe.gov

For print copies of DOE, EERE, and ITP Publications, contact -
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program

Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program

Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program

A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program

Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program

Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program

Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program

Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program

Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program

Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program

Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Aluminum Industry of the Future

Industrial Technologies Program

Boosting the productivity and competitiveness of U.S. Industry



U.S. Department of Energy
Energy Efficiency
and Renewable Energy

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